CHAPTER VII

EMPIRICAL RESULTS: MULTINOMIAL LOGIT MODEL

We present the multinominal logit estimation results in this chapter. First, we discuss the empirical basis for our definition of the number of active hours in a day. This parameter choice then affects the definition of the choice set for individuals, particularly on the shorter duration trips of one and two days. We then report estimates of the nested multinomial logit model. The major portion of the chapter focuses on estimates of the determinants of site choice for each of the six product lines. The final segment presents estimates of the second level of the nested structure, the choice of fishing product line.

In this chapter the model we estimate is based on the assumption that total trip time is exogenous for individuals when they are making their choice of which site to visit. In other words, if they had chosen any other feasible alternative in their choice set, the total trip time would have been the same as it was for the chosen site. As we argued in Chapter III we have chosen this model as our base case because we believe it incorporates a more consistent treatment of time than the others appearing in the literature. In the Appendix we explore the sensitivity of the model to the alternative assumptions about trip time discussed in Chapter III.

Choice Set Computation: Implementation Details

To define the individual choice set of feasible sites, as discussed in chapter III, we choose a value for the active hours h per day to include people whose trip durations are within two standard deviations above the mean of all people having the same number of trip days.[1] Consider the means and standard deviations of the observed trip time for people whose trips last from 1 to 7 days below,

Trip days, D	1	2	3	4	5	6	7
Trip time, T	7.56	25.77	52.65	77.84	101.21	126.46	152.17
	(3.85)	(11.05)	(6.36)	(6.43)	(6.59)	(5.76)	(6.03)

Let μ_D and σ_D denote the mean and standard deviation of the trip time T in hours for the observed D-day trips. The criterion we adopt is to select an h such that, for any D.

$$(D-1)\cdot 24 + h \approx \mu_D + 2\sigma_D.$$

Consequently h = 17 is used for the calculation of individual choice sets in the MNL site analysis. People whose trip durations are greater than $(D-1)$ 24-17 are deleted as outliers.[2]

The Site Choice MNL Estimation

The MNL model is first applied repeatedly to the 18 PL-duration subsamples (6 PLs by 3 durations) to estimate the parameters of the PL-specific site utility functions. The inclusive value of the sites for each PL-duration group is calculated from this analysis. For each duration group, the six PL subsamples are then pooled together and MNL is again used to model the PL decision.

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[1] This is a somewhat arbitrary decision. If a small value is used, we not only lose a lot of observations for individuals who chose sites we define as infeasible for them but we may also exclude sites that people actually consider visiting when making site choices. On the other hand, for some people we may be defining the choice set too broadly.

[2] Fewer than 2% of the total observations were excluded due to this time constraint violation.

Great Lakes Coldwater Product Line.

Table VII.1 presents the MNL estimation results for the Great Lakes cold water product line. All parameters are estimated with signs consistent with *a priori* predictions, except for the *Lake Trout* catch rate in the Wkn sample. The *Forest* variable is significant for all three duration groups, as is the *AOC* indicator. The *Feature* variable is significant for the longer trips (i.e., Wkn and Vac groups). Most catch rate variables are significant except *Rainbow Trout*. The catch rate of *Brown Trout* is not used because it does not have much variation across counties. The access variables (parking, harbor, slips, and ramps) are also excluded due to concern they may be endogenously determined.[3] Due to the limited observations we have in some of the 18 PL- duration subsamples, we cannot incorporate site dummies to estimate the site-specific constant terms in the utility function.[4]

The travel cost coefficients provide estimates of the marginal utility of income (MUI) for each group. As expected, the MUI decreases as the constraint on available opportunities relaxes from the Day group to the Wkn and Vac groups.

The model predicts 51% of the actual choices made by the *Day* group, which indicates that destination decisions for short trips are substantially driven by geographical proximity. As the importance of geographical proximity declines with increasing trip duration, the model is less effective in capturing the other factors influencing choices: correct predictions are 15% and 14%, for Wkn and Vac groups respectively.[5]

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[3]The State has attempted to construct access facilities at popular sites to accommodate demand, which suggests a reverse causation as well as a direct causation from available facilities.

[4]Some subsamples have even fewer observations than the number of sites

[5]These low percentages can also be attributed to the larger choice sets of Wkn and Vac trips. On average, number of feasible sites in a Wkn or Vac choice set is about twice that in a Day choice set.

Great Lakes Warmwater Product Line

Table VII.2 presents the MNL estimation results for the Great Lakes warmwater product line. The *Forest* variable is not significant for the Day and Wkn groups, but is positive and significant for the Vac group. *Feature* has a positive sign and is significant for the longer trips. These parameter estimates are consistent with our expectation that people who stay longer on a site will care more about environmental amenities. *AOC* is not significant for the shorter trips. For the Vac group, *AOC* is significant but the sign is opposite our expectation.[6]

The catch rate estimates are mostly significant for the Vac trips. Only *Northern Pike* is significant for the Wkn group and none is significant for the Day group. Some species have a negative sign for some duration groups, possibly due to high correlation among the catch rates, but they are not significant in those cases.

Anadromous Run Product Line

Table VII.3 presents the MNL estimation results for the Anadromous run product line. The presence of lakes or reservoirs is important, as manifested by the significance of the *Lake* dummy variable: when lakes occur in anadromous streams in a county, anglers can choose either boat- or shore-based angling. The *AOC* variable is significant for all trips, but has a positive effect on day-trip anglers. The positive *AOC* parameter estimate for Day group may be picking up non-linearities in the utility function with respect to travel distance (and cost). Most of the population is in the southeast Michigan, and for those individuals, most nearby counties are Areas of Concern.

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[6]According to Douglas Jester of the MDNR Fisheries Division, the reason for this perverse result is that Saginaw Bay, where people go on longer trips, is one of the few areas with high walleye catch rates, and also is one of the Areas of Concern.

Chinook and *Rainbow* salmon catch rates are also important factors affecting people's site choice decision, whereas *Coho* is not.

Inland Coldwater Product Line

Table VII.4 presents the MNL estimation results for the inland coldwater (lakes and streams) product line. Most parameters are imprecisely estimated, perhaps in part because we have pooled two product lines, each with small sample sizes. Unexpectedly, we do not pick up a significant positive effect for the opportunity to do fly fishing at a site, as the lackluster results for the *IScdFly* dummy shows. *AOC* is not significant for any group. The Area of Concern designation primarily applies to Great Lakes contamination, so it is not surprising that it is not as much of a concern for inland anglers as for Great Lakes anglers.

The coldwater stream miles variables and the Forest variable are highly correlated ($p > .6$); we attribute the mixed performance of the stream miles variables to the correlation. The negative parameter estimates for the stream contamination measure *CntmSC* indicate that anglers avoid contaminated streams when making a site decision, except for the Wkn sample (which has an insignificant positive parameter estimate). The fish consumption advisory variable for coldwater lakes *CntmLC* is not significant (except for Wkn where it has a significant and perverse effect). These results probably reflect the lack of variation in the variable: only two counties have fish consumption advisories on coldwater lakes.

Inland Lakes Warmwater Product Line

Table VII.5 presents the MNL estimation results for the inland lake warmwater product line. The parameters of the environmental amenities variables *(AOC, Forest, and Feature)* are precisely estimated with predicted signs. Note this is the only inland product line for which *AOC* parameter estimates are significant. The acres of inland warmwater lakes variables are very significant; the variables measuring acres of two-story lakes are only significant for the Vac group. *GntmLW* is not significant, which again probably reflects the lack of variation in the variable: only three counties have fish consumption advisories on warmwater lakes.

Inland Streams Warmwater Product Line

Table VII.6 presents the MNL estimation results for the inland stream warmwater product line. *Feature* is significant, with the predicted sign, for the longer trips, and *Forest* is significant for all duration groups. The *AOC* dummy is not significant for any duration group. The negative coefficients on the fish consumption advisory - variable border on significance at the 10% level for the Wkn and Vac groups. All the top quality stream parameter estimates have positive signs: the main stream variables are significant; the tributary stream variables are not, though in the Vac group it borders on 10% significance. All the second quality stream variables have negative parameter estimates though none is precisely estimated.

The Product Line Choice MNL Estimation

The following variables are considered relevant when people make product line choices:

- The inclusive value *(SiteIV)* as an index of the potential utility the sites of a PL can offer.
- The favorite catch species *(FavCatch)* dummy. People indicated in the questionnaire which species (out of a total of 16 species) they like to catch most.[7] The product lines that contain the individual's favorite species have a value of 1, otherwise they are set to 0.[8]

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[7]The species composition of the six product lines are not mutually exclusive. For example, the Great Lakes coldwater and the inland coldwater product lines overlap. The Great Lakes warmwater and the inland warmwater product lines also share most of their fish species.

[8]People also indicated in the survey what their favorite eating species are. This variable is not used because it is highly correlated with the favorite catch species.

- The favorite water type *(FavWater)* dummy. people revealed their water type preference among Great Lakes, inland lakes, and streams/rivers. Product lines whose water type is favored have a value of 1, and 0 otherwise.[9]

- The expected supply costs *(Supplies$)*. To predict the supply costs of the different product lines, the self-reported supply costs are regressed on number of days in trip, angler party size, and the interaction of them separately for each product line. The estimated parameters are then used to calculate the projected product line costs.

- The expected boat costs (*Boat* $). similar regressions are run for the calculation of the boat costs as those for the supply costs. This is done, however, separately for people who own a boat and those who do not. The Great Lakes coldwater product line is the most costly in terms of both supply costs and boat use costs.

Because the favorite species and favorite catch variables are so closely correlated with the product line choices, we report regression results without those variables. When those variables (with an average value of .8) are included, their power overwhelms the effect of some of the other variables. We include five product line dummies, with the Great Lakes coldwater (GLcd) dummy omitted as the base case.

Table VII.7 presents the MNL estimation results for anglers' product line choice. All parameter estimates of *SiteIV* are within the unit interval [0,1], which assures us that the NMNL model is not violating the consumer random utility maximization assumption. Also the coefficients of *SiteIV* are significantly different from 1 at 1% level for all three duration groups, Therefore, the simple logit, in which the *SiteIV* coefficient is assumed to be 1, is rejected.

The parameters of the supply and boat use costs are positive for some duration groups, contrary to expectations. It is possible that by incurring higher costs of some sort, people will also produce a higher quality experience which is not captured through any of the other variables. For example, the use of bigger boats may provide

[9]We also know the fishing mode and method that are favored by anglers. This information, however, is not utilized because most PLs offer opportunities for the use of most modes/methods. Angler experience is not included as a variable either since only inland cold stream angling demands some skill.

access to fishing opportunities that otherwise are not available.

Table VII.1: MNL estimates for the GLcd product line

	Day Anglers	Wkn Anglers	Vac Anglers
Dist$/100	–17.39	–4.20	–2.40
	(-16.49)	(-10.77)	(-8.52)
AOC	–1.54	–1.75	–.98
	(-8.60)	(-8.07)	(-4.26)
%Forest	2.34	1.23	2.26
	(4.13)	(3.14)	(4.74)
Feature	0.08	0.51	0.60
	(0.38)	(3.15)	(3.62)
Chinook Salmon	8.37	8.93	9.73
	(3.88)	(5.66)	(5.62)
Coho Salmon	3.93	5.37	5.06
	(1.90)	(3.34)	(3.20)
Lake Trout	3.31	–1.27	3.93
	(1.66)	(-0.49)	(3.40)
Rainbow Trout	2.21	2.47	3.45
	(0.42)	(0.70)	(0.88)
Log Likelihood	–520.2	–795.7	–625.2
x^2- test	737.5	321.3	205.3
%Choices Right	50.9	15.3	13.8
#People[MI/non-MI]	338[327/11]	195[151/44]	195[151/44]
#Choices	5624	10201	7785

Note: Numbers in parentheses are *t*- statistics.

Table VII2: MNL estimates for the GLww product line

	Day Anglers	Wkn Anglers	Vac Anglers
Dist$/100	-17.34	-3.49	-1.47
	(-22.17)	(-7.86)	(-5.01)
AOC	-0.05	-0.23	0.60
	(-0.30)	(-0.90)	(2.92)
%Forest	-0.93	-0.34	2.21
	(-1.40)	(-0.59)	(3.06)
Feature	0.20	0.84	1.62
	(0.53)	(3.01)	(6.34)
Yellow Perch	0.08	0.13	0.12
	(1.09)	(1.36)	(0.94)
Walleye	-0.20	0.53	3.23
	(-0.34)	(0.46)	(2.32)
Northern Pike	0.73	10.45	26.91
	(0.08)	(2.52)	(7.46)
Smallmouth Bass	9.37	-22.61	21.76
	(1.00)	(-1.28)	(2.36)
Carp	2.97	-5.43	3.92
	(1.95)	(-1.48}	(2.08)
Log Likelihood	-824.2	-424.3	-389.3
x^2- test	1743.3	159.9	195.3
%Choices Right	62.7	12.9	18.2
#People[MI/non-MI]	668[654/14]	140[133/7]	132[105/27]
#Choices	10179	5250	5280

Note: Numbers in parentheses are t- statistics.

Table VII.3: MNL estimates for the Anad product line

	Day Anglers	Wkn Anglers	Vac Anglers
Dist$/100	-15.72	-2.66	-1.45
	(-10.10)	(-5.89)	(-3.09)
AOC	0.66	-0.86	-1.91
	(2.56)	(-2.64)	(-3.18)
Lake	0.63	0.86	0.79.
	(2.44)	(3.89)	(3.01)
Chinook Salmon	2.53	4.04	4.42
	(3.53)	(9.33)	(9.15)
Coho Salmon	-0.85	-8.80	0.88
	(-0.27)	(-1.72)	(0.43)
Rainbow Trout	9.49	6.13	6.15
	(4.63)	(4.67)	(3.93)
Log Likelihood	-173.5	-309.4	-224.2
X^2- test	276.7	177.8	157.0
%Choices Right	67.5	15.9	13.8
#People[MI/non-MI)	123[113/10]	107[77/30]	80[40/40]
#Choices	2133	4475	3520

Note: Numbers in parentheses are *t*- statistics.

Table VII.4: MNL estimates for the LScd product line

	Day Anglers	Wkn Anglers	Vac Anglers
Dist$/100	-24.49	-5.08	-2.13
	(-14.44)	(-9.20)	(-6.11)
AOC	0.13	0.18	-0.12
	(0.39)	(0.48)	(-0.30)
Forest	4.90	7.36	5.76
	(4.40)	(9.09)	(6.81)
Feature	-0.21	-0.22	-0.38
	(-0.64)	(-0.82)	(-1.26)
IScdFly	0.32	-0.19	0.23
	(0.86)	(-0.63)	(0.70)
IScd1main/100	-0.32	1.11	0.27
	(-1.05)	(3.15)	(0.69)
IScd1trib/100	-0.59	0.40	0.15
	(-0.92)	(0.76)	(0.30)
IScd2main/100	0.48	0.03	0.23
	(2.19)	(0.18)	(1.45)
IScd2trib/100	0.44	-0.08	0.06
	(1.66)	(-0.44)	(0.33)
SCnec/100	-0.27	-6.97	1.52
	(-0.11)	(-2.34)	(0.75)
CntmSC	-0.13	0.02	-.14
	(-1.88)	(0.39)	(-1.84)
ILTotCd/100	0.003	0.001	0.002
	(1.49)	(0.74)	(1.08)
CntmLC/100	0.10	0.43	0.11
	(0.37)	(2.10)	(0.55)
Log Likelihood	-243.0	-466.0	-392.3
X^2- test	671.1	383.8	176.6
%Choices Right	69.3	20.6	9.8
#People[MI/non-MI]	192[187/5]	155[143/12]	112[97/15]
#Choices	5343	10977	8176

Note: Numbers in parentheses are *t*- statistics.

Table VII.5: MNL estimates for the ILww product line

	Pay Anglers	Wkn Anglers	Vac Anglers
Dist$/100	-23.66	-5.15	-1.71
	(-35.29)	(-18.60)	(-14.20)
AOC	-0.43	-0.81	-0.65
	(-4.31)	(-5.34)	(-4.88)
Forest	2.83	3.62	2.83
	(6.79)	(12.06)	(11.59)
Feature	0.21	0.33	0.54
	(1.53)	(2.59)	(5.68)
ILwwacre/100	0.007	0.006	0.007
	(12.14)	(9.74)	(14.84)
IL2story/100	0.0004	0.0003	0.0027
	(0.35)	(0.37)	(5.66)
CntmLW/100	-0.0006	0.006	0.016
	(-0.40)	(0.24)	(0.74)
Log Likelihood	-1645	-1613	-2455
x^2- test	3353.2	791.5	870.7
%Choices Right	61.2	10.5	8.6
#People[MI/non-MI]	989[949\40]	459[369/90]	654[470/184]
#Choices	35284	36941	54282

Note: Numbers in parentheses are *t*- statistics.

Table VII.6: MNL estimates for the ISww product line

	Day Anglers	Wkn Anglers	Vac Anglers
Dist$/100	-26.47	-6.08	-3.75
	(-17.46)	(-7.95)	(-7.70)
AOC	-0.06	0.15	-.14
	(-0.26)	(0.44)	(-0.40)
Forest	1.81	3.88	6.37
	(2.09)	(4.79)	(7.46)
Feature	-.29	0.79	0.64
	(-0.83)	(2.54)	(2.48)
ISww1main/100	0.82	1.67	1.10
	(2.55)	(3.63)	(2.48)
ISww1trib/100	0.56	0.64	0.87
	(1.12)	(0.93)	(1.57)
ISww2main/100	-0.16	-1.02	-0.60
	(-0.61)	(-1.88)	(-1.29)
ISww2trib/100	-0.24	-0.37	-0.02
	(-1.73)	(-1.79)	(-0.10)
ISwwNEC/100	-1.39	2.56	4.03
	(-0.93)	(1.23)	(2.01)
CntmSW	-.002	-0.028	-0.098
	(-0.19)	(-1.63)	(-1.59)
Log Likelihood	-349.9	-249.5	-3112.8
x^2- test	887.2	136.7	160.9
%Choices Right	73.2	21.9	14.6
#People[MI/non-MI]	246[240/6]	73[67/6]	89[67/22]
#Choices	8100	5747	7387

Note: Numbers in parentheses are *t*- statistics.

Table VII.7: MNL estimates for the product line choice

	Day Anglers	Wkn Anglers	Vac Anglers
SiteIV	0.925	0.438	0.246
	(26.66)	(5.58)	(2.80)
Supplies$/100	0.034	-0.021	0.003
	(3.37)	(-1.46)	(0.72)
Boat$/100	0.015	0.001	0.002
	(1.97)	(0.80)	(0.48)
GLww(dummy)	1.579	-0.899	-0.657
	(13.31)	(-3.67)	(-2.88)
Anad(dummy)	-0.995	-0.902	0.285
	(-5.594)	(-3.94)	(1.53)
LScd(dummy)	-1.975	-2.707	-1.070
	(-12.90)	(-6.40)	(-3.06)
ILww(dummy)	0.359	-0.868	0.922
	(2.63)	(-2.52)	(3.45)
ISww(dummy)	-.191	–2.461	-1.170
	(-1.451)	(-7.45)	(-3.95)
Log Likelihood	-3422	-1844	-1730
x^2- test	1928.8	429.8	770.2
%Choices Right	50.5	38.9	51.8
#People	2580	1196	1262
#Choices	14213	6715	6769

Note: Numbers in parentheses are *t*- statistics.

CHAPTER VIII

EMPIRICAL RESULTS: THE PARTICIPATION MODEL

We report the estimation results of the competing risks model in this chapter. We first present the exponential model estimates. We then report the Weibull model estimates, which allow us to test the duration independence assumption of the exponential model,

Variable Definitions and Analysis Sample

For the participation model, we estimate the determinants of individuals' choices about how many trips of different durations to take during a fishing season. The explanatory variables include

- *IV:* The inclusive value of the product lines and sites available to an individual. This variable varies with time and is computed for each month in the open-water season (April - October) from the NMNL estimates.

  We showed above in chapter III, equation (III.15), that the inclusive value index could be decomposed into the sum of three terms: the pseudo-IV (which does not include the unmeasured choice occasion income), the choice occasion income, and an individual specific constant term. This variable is the pseudo-IV. As noted below, we substitute an alternative income measure below for the (unmeasured) choice occasion budget. The individual-specific term is captured by the variables measuring individual characteristics. Because we substitute for the components of the IV, we do not constrain the parameter estimates of the various substitute variables to be equal.

- *WageCost:* The measure of the opportunity wage cost of taking a fishing trip, which equals the after-tax wage rate times the number of trip-hours. (In Table VIII.1, we report the values of the after-tax wage variable.)
- *HHY:* Individual annual household income is substituted for the unknown choice-occasion budget for recreational fishing.[1]
- *ExpRate:* (0,1) dummy, =1 for people self-reported as "experienced" or "expert"; =0 for people self-reported as "beginner" or "somewhat experienced".
- *No Work:* (0, 1) dummy, =1 if the respondent is a student, unemployed, or retired.
- *NoSpouse:* (0, 1) dummy, =1 if the respondent does not have a spouse.
- *SpNoFish:* (0, 1) dummy, =1 if the respondent is married and his/her spouse does not fish.
- *NoKids:* (0, 1) dummy, = 1 if the respondent has no child under 16 years old.

Table VIII.1 presents the descriptive statistics of the age duration and the explanatory variables for the analysis sample. The mean and standard deviation of the *IV* variable are not reported because *IV* varies with time. The sample sizes in this table represent all observations included in the participation estimation. The full sample of the 5376 observations comprises four subsamples:

1. The *Day* group — 2258 people whose last trips are day trips.
2. The *Wkn* group — 1070 people whose last trips are weekend trips.
3. The *Vac* group — 1105 people whose last trips are vacation trips
4. The *Non-Partic* group — 867 people for whom no trip was observed taken.

We split the *Non-Partic* group into two types of people: (1) the 582 people who did not report a trip *(No- Trip)* and (2) the 285 people whose reported trip is not suitable for being counted in the welfare analysis ***(Inelig Trip)***.[2] The "true" non-participants

[1]We can interpret this substitution to be in the spirit of the lifetime income framework, which posits that people can borrow and lend freely across time periods.

[2]A trip is labeled as uncountable either because fishing was not a purpose of the trip or because the trip was longer than 16 days, and so was motivated by many purposes besides recreational fishing.

did not take a trip between the beginning of the 1983 open-water fishing season and their questionnaire return date, which ranges from seven to fourteen months. Therefore, their sampled between-trip duration is left truncated at April 1, 1983 and fight truncated at the questionnaire return date. For the people last trip is not a "countable" fishing trip, we can only conclude that no "countable" fishing trip has occurred between the time the uncounted trip was taken and the time the questionnaire was returned, which ranges from one to nine months (with one outlier at thirteen months). Therefore, the sampled between-trip duration is left-truncated by the trip that is not countable and right-truncated at the return of the questionnaire.

The distribution of the age durations (or the censored ages for the non-participants) in our sample is presented in table VIII.2. The different selection processes for the two sub-groups of non-participants are clearly evident in the lower means and ranges of the age variable for the *Pseudo-Trip* group. Since we only consider the open-water fishing season (from April to October), a "year" consists of only seven months.

The Day, Wkn and Vac samples are smaller than their counterparts used in the MNL analysis because we had to delete the people for whom we did not have the questionnaire return dates or the last trip dates. For the MNL analysis, we only need to know the month during which the trip was taken. For the participation analysis, however, we require the complete month/day/year information in order to calculate the age duration.[3] Also, people whose questionnaires were returned on the same day that their trips ended are excluded because they might have waited until after their next trip to fill out (and mail) the questionnaires. In such cases, these two dates are not independent and our random censoring assumption is violated.

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[3]Actually we can further exploit interval information on age. For anglers for whom we only have month and year data, for example, we can calculate upper and lower bounds of the age duration and include an integral term (instead of a density term) in the likelihood function.

Participation Model Estimates

Table VIII.3 presents the parameter estimates of the exponential competing risks model. The *IV* parameter indicates that there is a positive relationship between trip value and number of day and weekend trips taken by anglers, as predicted; however; the relationship is negative for vacation trips. The parameter estimates are significant for all trip lengths, Therefore, people are likely to take more day and weekend trips, but fewer vacation trips, when trip value is higher.

The *WageCost* variables are only significant (with the predicted negative effect) for Day trips; the probabilities of taking a weekend or vacation trip do not appear to be sensitive to the wage costs of the trips. People with higher household incomes *(HHY)* tend to take more trips of all durations than lower income people. Greater angler experience *(ExpRate)* is also associated with greater participation intensity.

To interpret the effect of not working *(NoWork* = 1, for students, unemployed and retired people), we need to consider the combined impact of *NoWork* and *WageCost,* where the wage cost is positive only for employed anglers. Though the *NoWork* coefficient estimates are negative for all three duration groups, the net effect of not working is negative only for Wkn and Vac (for which *WageCost* is not significant). Consequently, the results indicate that non-working individuals are more likely than working individuals to take day trips. The negative parameter estimate on *NoWork* indicates there is a non-linearity in the relationship between participation probabilities and *WageCost* when an individual does not earn wages.

To interpret the effect of marital status and whether a spouse fishes, we need to look at both *NoSpouse* and *SpNoFish* variables. An angler is assigned to one of three categories: (1) single, (2) married and spouse does not fish, or (3) married and spouse fishes (the excluded category). For the single anglers, *NoSpouse* = 1 and *SpNoFish* = 0. For the married anglers (with *NoSouse* = 0), *SpNoFish* = 1 if their spouses do not fish, and = 0 otherwise. The parameter estimates indicate that, relative to having a spouse who fishes, having a spouse who does not fish significantly lowers the probability of taking the longer trips. Being single does not have significantly different effects than having a spouse who fishes, though a dampening effect on the vacation probability does approach significance at the 10% level. Referring to table VIII. 1, we know that the four analysis subsamples have the following distribution:

Status	No-Trip	Pseudo-Trip	Day	Wkn	Vac
Single	26%	22%	23%	20%	19%
Married, SpNoFish=1	31%	27%	28%	27%	24%
Married, SpNoFish=0	43%	51%	49%	53%	57%

Note a larger proportion of the non-participants are single or have spouses who do not fish: this contributes to the negative parameter estimates of the *NoSpouse* and *SpNoFish* variables. Having no children under 16 years old also reduces the probability of taking a day trips but has no effect on the probabilities of weekend or vacation trips. [4]These family variables do not have the large and significant effects of *IV*, *HHY*, and *ExpRate*.

The Weibull model reported in table VIII.4 yields scale parameter estimates very similar to, the values imposed in the exponential model. The existence of negative duration dependence is suggested by the negative shape exponent $\alpha = -0.022 < 0$. The shape parameter is calculated as $\gamma = e^{-0.022} = 0.978 < 1$. However, since the shape exponent α is not significantly different from 0, the exponential model is not rejected.

From the estimated parameters in the exponential and Weibull models, we calculate the predicted numbers of day, weekend, and vacation trips for the anglers in the analysis sample, which are reported in table VIII.5 The negative duration dependence in the Weibull model is sufficiently small that the predicted numbers of trips

[4]The estimated effect is only significant on Day trips.

of each type are essentially the same for both models.

In future work, it would be desirable to evaluate whether we should treat the non-participants differently from the participants in our analysis. In a population-based sample, non-participants will include respondents who clearly did not intend to participate (and who realized their intentions.) In contrast, our sample is restricted to people who purchased Michigan fishing licenses during the survey years: non-participants wanted the option to fish, but chose not to exercise the option. Nonetheless, it is possible that sample non-participants differ substantially from participants in their unobserved characteristics. Unfortunately, we do not have the data to identify special circumstances such as illness or unusually heavy work or family obligations, which could have been unanticipated at the time of the license purchases.[5] The suggestion of negative, duration dependence in our sample could be due to these or other sources of unobserved heterogeneity between the participants and the non-participants.

To test this hypothesis, a *conditional Weibull* model could be estimated with only the participants (conditional on participation during the survey seasons). If the original competing risks model is correct (i.e., no unobserved heterogeneity exists), the conditional Weibull estimates should be very close to those of the unconditional Weibull since the conditional Weibull involves only loss of efficiency.[6] This additional analysis was beyond the scope of this study.

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[5]Table VII. 1 shows that the sample means for the non-participant groups are different from those of the other three groups for key observed characteristics, though the differences are not significant (1) on average, the non-participants have lower wages and household incomes (2) they have less angling experience than people in the other groups; (3) a larger proportion of them do not work; (4) a larger proportion of them do not have a spouse; and (5) a larger proportion of them do not have children under 16 years old. In Table VIII.1, we also can see that the mean censored age duration of the non-participants is over three times the mean (uncensored) age for the Day and Wkn samples, and twice that of the Vac sample.

[6]Defining the distinction between participants and non-participants is more complicated in our dataset than with a more typical survey, in which total trips are measured for a fixed time period across all individuals. In our dataset, we observe “no trip” outcomes over very different time periods, ranging from one to fourteen months. To model “no-participation”, we must confront the question, “over what time period must a licensed angler not-participate to be considered a different type of person?”

External Validation of the Participation Model

In order to validate the participation estimates from the model, we compare total participation predicted by the model against participation estimates derived from another data source: mail surveys collecting participation diary data, sponsored by the Michigan Department of Natural Resources during years 1980-82. Because the process and criteria for counting trips and days are different in the two datasets, the comparison is not suited to statistical testing. The diary mail survey was a 1% sample of all licensed anglers, with a 62% response rate. The questions about trip participation elicited counts of angler-days over the prior three months, in single-month increments. In the table below, we report the number of angler days calculated directly from the data, by fishing product line. Two adjustments are then made to these estimates to provide a more appropriate estimate of open-water angler days. First, the MDNR estimates that the calculations overstate the number of annual angler days by 35% on average, based on comparison of these trip estimates against direct observation of participation in small area surveys.[7] To correct the overstatement, we divide the numbers by 1.35. Second, we adjust the total annual days by a factor of .9 in order to limit the estimate to open-water angling days only, for comparability with the sample employed in participation modeling. The adjusted totals are reported at the bottom of the table.

[7] Personal communication with Douglas B. Jester, Fisheries Division, Michigan Department of Natural Resources, 1992.

Angler-Days Estimated from the MDNR Diary Survey[8]

Product Line	1980	1981	1982
Great Lakes Coldwater	2,150	2,575	2,220
Great Lakes Warmwater	4,620	4,690	4,710
Anadromous Runs	1,430	1,735	1,270
Inland Coldwater	2,000	2,250	1,590
Inland Warmwater	11,200	12,150	11,010
Annual Total	21,400	23,400	20,800
Adjusted Total	14,267	15,600	13,867

To compare model predictions against the diary data estimates above, we translate the predicted number of fishing trips from the model reported in Table VIII.5 into angler-days and extrapolate from the analysis sample to the population of anglers. However, as noted above, the participation concepts are different in the two samples: the analysis of the MDNR diary mail survey is designed to be all-inclusive of fishing days, whereas our demand analysis is restricted to trips suitable for inclusion in a welfare analysis of the benefits of recreational fishing.[9] We incorporate a partial adjustment for this exclusion, as described below.

To calculate estimated angler days based on the recreational fishing model, we translate trips T into days D by multiplying the number of weekend trips by the sample mean weekend trip-length of 3.05 days, and the number of vacation trips by the sample mean vacation trip-length of 9.12 days.[10] The estimated total trips and angler-days for the 4433 participants and the 867 non-participants in our sample are presented in Table VIII.6, separately for each model.

Denote the predicted total number of (eligible) angler-days of the 867 non-participants in the sample by D_0 and that of the 4433 participants by D_1. We then

[8] The unit is thousand angler-days.

[9] On the other hand, the variable measured in the angler survey used in the participation modeling is number of trip-days.

[10] This is the average length of all trips between 5 days and 16 days in our sample.

extrapolate as follows:

$$\begin{aligned} D^* &= \frac{P}{N}\left[\frac{N_{0,N}}{S_{0,N}} \times D_{0,N} + \frac{N_{0,I}}{S_{0,I}} \times D_{0,I} + \frac{N_1}{S_1} \times D_1\right] \\ &= \frac{1414914}{10948}\left[\frac{1320}{582} \times D_{0,N} + \frac{1992}{285} \times D_{0,I} + \frac{7636}{4433} \times D_1\right], \end{aligned}$$

where P = 1,414,914 is the total angler population in 1983,
$N_{0,N}$ = 1320 is the number of no-trip people in the MDNR data,
$N_{0,I}$ = 1992 is the number of ineligible-trip people in the MDNR data,
N_1 = 7636 is the number of participants in the MDNR data, and
N = $N_{0,N} + N_{0,I} + N_1$ = 10,948 is the total sample size of the MDNR data.
$S_{0,N}$ = 582 is the number of no-trip people in our analysis sample,
$S_{0,I}$ = 285 is the number of ineligible-trip people in our analysis sample, and
S_1 = 4433 is the number of participants in our analysis sample.[23]

The total predicted (eligible) trip-days for the population, corresponding to the different models, are calculated to be

Model	$D_{O,N}$	$D_{O,I}$	D_1	D^*
Exponential	3,545	2,123	33,274	10,364,296
Weibull	3,518	2,122	33,124	10,322,086

The total angler-days estimated from our competing-risk model appears to be about 30% less than the MDNR diary mail survey estimate, *without any adjustment* for deletion from the sample of trips of longer than 16 days or trips not originally planned for the purpose of fishing. To take account of these 'ineligible' trips, we also report in Table VIII.6 the number of days of ineligible fishing trips *measured in the sample.* This is a very limited measure of omitted fishing days for the season: whereas all 5300 individuals in the sample may take multiple trips per season that would not be counted in the welfare analysis,[11] we only count the days of one trip and we count them only for those 285 people whose most recent trip was ineligible. We calculated the total trip-days of the 285

[11] The exception is the 582 people who took no trips over one 7-month open water season (or longer.)

people in the sample whose last trip was ineligible as $DNE_{0,1}$ = 3931. We extrapolate[12] this estimate to the population of anglers as follows:

$$DNE^* = \frac{P}{N} \times \frac{N_{0,I}}{S_{0,I}} \times DNE_{0,I} = \frac{1414914}{10948} \times \frac{1992}{285} \times 3931 = 3,550,935.$$

With the partial adjustment, the prediction is about the same magnitude as the MDNR figures. We infer that the differences in the definition of fishing days included in the estimates may account for the differences between estimates, though we have insufficient data to test fully the hypothesis. Though the differences in the concepts being measured limit our ability to compare the estimates, we conclude that the similarity of predicted participation between the model and the annual diary data provides some evidence corroborating the participation model.

[12]It is possible that sampling bias or selection bias exists in our extrapolation procedures. The individuals in both MDNR datasets were randomly sampled from the total licensed angler population; however, according to Douglas Jester of MDNR Fisheries Division, people who are less experienced or who fish less frequently do tend to be slower (and less likely) to return the questionnaires. As a consequence, we may have an upward bias in our participation calculation from both data sources.

Table VIII.1: Attributes of the participation analysis sample

	No-Trip	Inelig Trip	Day Trip	Wkn Trip	Vac Trip
[Censored] Age	246.96	98.01	58.89	64.10	92.11
(in days)	(54.03)	(56.21)	(50.83)	(54.57)	{52.46)
Wage	5.45	5.96	7.23	8.70	8.34
	(6.09)	(5.83)	(5.66)	(5.73)	(5.80)
$HHY/10^4$	2.20	2.45	2.65	3.02	2.98
	(1.54)	(1.47)	(1.52)	(1.57)	(1.50)
ExpRate	0.38	0.40	0.53	0.51	0.50
	(0.43)	(0.48)	(0.50)	(0.50)	(0.50)
NoWork	0.43	0.39	0.25	0.17	0.23
	(0.50)	(0.49)	(0.44)	(0.38)	(0.42)
NoSpouse	0.26	0.22	0.23	0.20	0.19
	(0.44)	(0.42)	(0.42)	(0.40)	(0.39)
SpNoFish	0.31	0.27	0.28	0.27	0.24
	(0.46)	(0.45)	(0.45)	(0.44)	(0.43)
NoKids	0.71	0.72	0.55	0.56	0.60
	(0.46)	(0.45)	(0.50)	(0.50)	(0.49)
N	**582**	**285**	**2258**	**1070**	**1105**

Note: Numbers in parentheses are standard deviations.

Table VIII.2: Distribution of the age (or censored age) duration length

#Months	No-Trip	Inelig Trip	Day Trip	Wkn Trip	Vac Trip	**Sub-Total**
1	0	22	718	274	122	**1136**
2	0	64	590	366	207	**1227**
3	0	56	423	151	224	**854**
4	0	58	253	108	243	**662**
5	0	36	142	64	152	**394**
6	0	24	67	61	96	**248**
7	372	14	31	25	38	**480**
8	0	5	21	13	17	**56**
9	82	5	10	6	5	**108**
10	57	0	2	1	1	**61**
11	11	0	1	1	0	**13**
12	0	0	0	0	0	**0**
13	53	1	0	0	0	**54**
14	7	0	0	0	0	**7**
Total	**582**	**285**	**2258**	**1070**	**1105**	**5300**

Table VIII.3: Competing risks exponential model estimates

	Day Trips	Wkn Trips	Vac Trips
Intercept	-6.459	-6.812	-5.791
	(-61.56)	(-50.22)	(-51.25)
IV	0.780	0.312	-0.437
	(17.53)	(5.71)	(-16.25)
WageCost/10^2	-1.879	-0.128	0.400
	(-2.50)	(-0.13)	(0.40)
HHY/10^4	0.045	0.123	0.096
	(2.30)	(4.41)	(3.51)
ExpRate	0.372	0.295	0.204
	(8.73)	(4.76)	(3.36)
NoWork	-0.326	-0.587	-0.213
	(-4.21)	(-4.94)	(-1.82)
NoSpouse	-0.019	-0.113	-0.130
	(-0.34)	(-1.30)	(-1.52)
SpNoFish	-0.048	-0.143	-9.264
	(-0.96)	(-1.96)	(-3.58)
NoKids	-0.259	-0.021	0.074
	(-5.43)	(-0.31)	(1.11)
Log Likelihood		-29219.5994	
x^2- test (DOF=27)		2791554.8012	
Likelihood Ratio Index		0.9795	

Note: Numbers in parentheses are t- statistics.

Table VIII.4: Competing risks Weibull model estimates

	Day Trips	Wkn Trips	Vac Trips
Shape exponent α		-0.022	
		(-1.78)	
Intercept	-6.455	-6.811	-5.787
	(-60.88)	(-49.93)	(-50.78)
IV	0.780	0.312	-0.440
	(17.36)	(5.69)	(-16.07)
WageCost/10^2	-1.909	-0.141	0.395
	(-2.51)	(-0.14)	(0.39)
HHY/10^4	0.046	0.124	0.096
	(2.31)	(4.41)	(3.51)
ExpRate	0.376	0.299	0.208
	(8.71)	(4.80)	(3.41)
NoWork	-0.331	-0.589	-0.215
	(-4.21)	(-4.94)	(-1.83)
NoSpouse	-0.020	-0.113	-0.129
	(-0.35)	(-1.30)	(-1.49)
SpNoFish	-0.049	-0.144	-0.265
	(-0.97)	(-1.96)	(-3.56)
NoKids	-0.260	-0.022	0.073
	(-5.39)	(-0.33)	(1.08)
Log Likelihood		-29217.9915	
X^2- test (DOF=28)		2791558.0169	
Likelihood Ratio Index		0.9794	

Note: Numbers in parentheses are *t*- statistics,

Table VIII.5: Predicted number of trips per angler in an open-water season

	N	Day Trip	Wkn Trip	Vac Trip
Exponential model:				
Day Sample	2258	1.255	0.549	0.442
Wkn Sample	1070	1.157	0.568	0.516
Vac Sample	1105	0.905	0.495	0.671
No Trip	582	0.916	0.422	0.426
Inelig Trip	285	0.875	0.426	0.580
Weibull model				
Day Sample	2258	1.248	0.546	0.440
Wkn Sample	1070	1.150	0.565	0.514
Vac Sample	1105	0.900	0.492	0.669
No Trip	582	0.910	0.419	0.423
Inelig Trip	285	0.869	0.423	0.578

Table VIII.6: Predicted number of total angler-days in an open-water season

	Day Trip	Wkn Trip	Vac Trip	**Total**
Exponential model:				
Total Trips (Participants), T_1	5072	2394	2292	– -
Total Days (Participants), D_1	5072	7303	20899	**33274**
Total Trips (No Trip), $T_{0,N}$	533	246	248	—
Total Days (No Trip), $D_{0,N}$	533	750	2262	**3545**
Total Trips (Inelig Trip), $T_{0,P}$	249	121	165	– -
Total Days (Inelig Trip), $D_{0,P}$	249	369	1505	**2123**
Weibull model:				
Total Trips (Participants), T_1	5043	2381	2283	– -
Total Days (Participants), D_1	5043	7262	20819	**33124**
Total Trips (No Trip), $T_{0,N}$	530	244	246	—
Total Days (No Trip), $D_{0,N}$	530	744	2244	**3518**
Total Trips (Inelig Trip), $T_{0,P}$	248	121	165	– -
Total Days (Inelig Trip), $D_{0,P}$	249	369	1505	**2122**

CHAPTER IX

POLICY APPLICATION: LUDINGTON PUMPED-STORAGE PLANT

Biological Scenarios

The economic principles of natural resource damage assessment can be illustrated in the context of an important liability case in which the State of Michigan is suing for damages as a result of fishkills attributable to the operation of the Ludington Pumped-Storage plant on Lake Michigan.[1] A related action has also been brought by the State and the National Wildlife Federation before the Federal Energy Regulatory Commission, which licenses hydro-power plants.

The largest hydropower facility of its kind in the country, the pump-storage plant is responsible for the largest continuous fishkill in Michigan waters. Designed to serve the peak load requirements of Michigan electric consumers, it pumps water from Lake Michigan to a storage reservoir 360 feet above lake level during low-demand periods and releases it back to the lake through six power-generating turbines during peak-demand hours. When operating at full capacity, the plant is capable of producing 1.8 million kilowatts of electricity. Millions of fish are killed every year as they are pumped in with water currents traveling at up to 6 ft/sec and later released through

[1] Civil Action No, 86-7075-CE, State of Michigan Circuit Court.

the pump-turbines. Death occurs as a result of pressure changes, direct contact with the pump-turbine blades, and associated stress.

A study commissioned by the utilities that own the power plant estimated that in 1980 the plant killed, among other fish, 1.1–3.2% of the entire biomass in Lake Michigan of alewife, a forage species necessary to support the stocked recreational trout and salmon fisheries, and 5.6% of adult-equivalents for combined angler harvests of five trout and Salinon species. The trout and salmon fisheries most heavily affected by the power plant are completely allocated to recreational uses.

Baseline: Current Plant Operation

This baseline situation represents the operation of the Ludington plant without fish protection measures, from the initial plant startup in 1971 through 1988. Catch rates under this situation are adequately represented by the catch rates used in the estimation of the discrete choice NMNL model.

Termination of Plant Operation

This scenario[2] is designed to capture the change in fishing quality that would occur if all fish mortalities associated with plant operations were eliminated, either by fish protection measures or termination of plant operations. Catch rates under this scenario are higher than in the base scenario for two reasons: sport fish killed by the plant would remain in the stock, and, more importantly, forage fish killed by the plant would be available to support additional stocks of sport fish. Forage is a limiting factor in the current State program for stocking trout and salmon in the Great Lakes.

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[2]This Ludington pumped-storage plant biological scenario is provided by Douglas B. Jester of the Michigan Department of Natural Resources Fisheries Division.

Salmon and trout catch rates throughout Lake Michigan would be affected since migration of the salmonid species and the forage fish would rapidly diffuse the effects of a change in mortalities at the Ludington-Pumped Storage plant.[3] Catch rates in anadromous fisheries for trout and salmon upstream from Lake Michigan would also be affected in the same Lake Michigan counties and in some inland counties.[4]

According to the MDNR scenario: the termination of plant operations would improve both Great Lakes and anadromous fisheries for trout and salmon in and along Lake Michigan at the following rate:

Product Lines	Species	Increase in Catch Rate
GLcd, Anad	Chinook Salmon	10.0%
	Coho Salmon	3.3%
	Lake Trout	13.7%
	Rainbow Trout	8.6%

Catch rates of other species are unlikely to change outside the immediate plant area of Mason (53) and Oceana (64) counties. Among the warmwater species killed by the plant, yellow perch is the only recreational species killed in significant numbers and included in the MNL model specifications. For these two counties, the scenario specifies that yellow perch catch rates would increase by approximately 7% if yellow perch were not killed by operations of the plant. All of the above catch rate changes are predicted to occur across all months of the year. The 22 Michigan counties affected by the operation of the Ludington plant are shown in map IX.1.

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[3]Lake Michigan counties affected include: Allegan (3), Antrim (5), Benzie (10), Berrien (11), Charlevoix (15), Emmet (24), Grand Traverse (28), Leelanau (45), Mackinac (49), Manistee (51), Mason (53), Muskegon (61), Oceana (64), Ottawa (70), Schoolcraft (77), and Van Buren (80). Two Green Bay counties, Delta (21) and Menominee (55), are the only exceptions.

[4]These inland counties are Eaton (23), Ingham (33), Ionia (34), Kent (41), Lake (43), and Newaygo (62).

Consumer Surplus Calculation

To estimate people's willingness-to-pay (WTP) for the termination of Ludington plant operations, we first calculate the seasonal compensating variation for the analysis sample according to formula V.28 in chapter V:

$$W = \sum_i \sum_m \sum_d \left[\frac{T^1_{imd} \cdot \bar{I}^1_{imd} - T^0_{imd} \cdot \bar{I}^0_{imd}}{\tilde{\eta}_d / 100} \right]$$

where

i indexes individuals in the sample of our consumer surplus analysis.

m indexes months (April — October) in an open-water season.

d indexes types of trips (= Day, Wkn, Vat).

0 refers to the "with plant operations" case.

1 refers to the "no plant operations" case,

$\tilde{\eta}_d$ is the weighted (across product lines) MUI per \$100 for trip duration type *d*.

T is the predicted number of total trips in a season.

$\bar{I}$ is the pseudo-IV variable defined in chapter III.

The multiplication by 100 is to correct for the fact that the unit of the marginal utility of income parameter $(\tilde{\eta}_d)$ is utility-per-\$100 because the distance cost variable is divided by 100. Table IX.1 presents, separately for each duration group, the compensating variation per trip $(\bar{I}^1_{id} - \bar{I}^0_{id}) \times 100/\tilde{\eta}_d$ in 1984 dollars (averaged over the seven open-water fishing months) associated with the fishkill caused by the Ludington operations, conditional on the trip type being chosen. The expected increase in value per trip is small since only a few product lines and sites are affected. Table IX.2 reports the predicted number of season trips T^0 with the plant operating. Since the exponential model is not rejected when tested by estimating the Weibull model, we use the exponential estimates in the calculation. Tables IX.3 and IX.4 report the predicted change in total trips $(T^1_{id} - T^0_{id})$ and the total compensating variation (W_d)

in 1984 dollars for one open-water season if the operation of Ludington plant were terminated. We predict fewer vacation trips from the termination of the plant because the *IV* parameter estimate of the participation model is negative for the vacation trip. Therefore, higher *IV* will lead to a reduction in the vacation trips. The total seasonal compensating variation for the sample is thus calculated to be W = \$1939. 71 (in 1984\$) from the subtotals in table IX.4.

We then extrapolate the sample CV to the population as

$$\begin{aligned} W^* &= \text{CPI}\left(\frac{91}{84}\right) \times \frac{P}{N} \times \frac{N}{S} \times W \\ &= 1.348 \times \frac{1414914}{10948} \times \frac{10948}{4824} \times 1939.71 \\ &= \$766{,}219.03 \end{aligned}$$

where P = 1, 414, 914 is the total population of licensed anglers in 1984, N = 10,948 is the sample size of the MDNR data, and S = 4824 is the number of people in our consumer surplus analysis. N/S is the factor for extrapolating from the consumer surplus sample to the MDNR sample. P/N is the factor for extrapolating from the MDNR sample to the total population of licensed anglers. Because the trip choices and associated expenditures were incurred in 1983 and 1984, the measure is in 1983 or 1984 dollars until corrected with a current price index.[5]

Therefore, the final extrapolation from the sample to the population of licensed anglers yields an annual damage estimates of \$0.77 million (in 1991\$) from the operation of the Ludington Pumped-Storage plant.

[5]The current consumer price index 1.348 we use here is the 1991 (February) price relative to the base years 1982-84. This information is obtained from the "Consumer Price Index for All Urban Consumer (CPI-U)" table in the *Summary Data from the Consumer Price Index News Release February 1991*, published by the Bureau of labor statistics, US Department of Labor.

Comparison With Other Estimates

Previous recreation demand studies have generated consumer surplus measures corresponding to various site condition changes. For example, Bockstael et al. (1988) estimate that the consumer surplus per choice occasion associated with a 20% increase in the game fish catch rates ranges from $.32 to $1.56, depending on species affected, in their Florida (Atlantic coast) sport fishery study. For a 25% increase in fish catch rates on Aibemarle and Pamlico Estuaries, the nested logit estimation of Smith and Palmquist (1988) yields an angler welfare change of $2.43 per trip when all sites are affected, or $ .60 when only the closest four sites are affected. To calculate. a consumer surplus per choice occasion from the Michigan recreational fishing study that is comparable in definition to other estimates, we proceed as follows.[6]

First, under the competing risks framework, an angler has a certain probability of taking a trip of each type on any choice occasion. The compensating variations reported in table IX.1 are conditional compensating variations per choice occasion ($CCOCV_d$), for specific trip types *d* being chosen, (conditional upon participation). To calculate the average conditional compensating variation per trip (*CCOCV*), we have to weight each $CCOCV_d$ by its corresponding probability. Here we use the angler distribution in the sample of the participants (N=4824) as an approximation of the probabilities.

[6]We cannot compare seasonal consumer surplus because people living in different geographical locations are likely to have different participation rates due to different fishing opportunities. Therefore, consumer surplus per choice occasion, conditional upon participation, is the only measure that we can reasonably compare across studies. We expect this measure to vary across contexts, because it is influenced by the distance between the population of anglers and the fishing sites in consideration and by quality levels.

Trip Type	Probability	$CCOCV_d$	Prob x $CCOCV_d$
Day	2463/4824=51%	.04	.02
Wkn	1159/4824=24%	.17	.04
Vac	1202/4824=25%	.24	.06
Sum			**.12**

The probability that an individual will choose GLcd or Anad, the two product lines most affected by the Ludington scenario, is approximated by dividing the number of anglers in GLcd (N=769) and Anad (N=299) samples by the number of total participants (N=4824). The compensating variation per choice occasion of an angler targeting GLcd or Anad is, therefore.

$$\$.12 \div \left(\frac{769 + 299}{4824}\right) = \$.542$$

Since only half of the 41 Great Lakes counties are affected, we have $.542 x 2 = $1.084 (in 1984$) as the projected average CCOCV of a GLcd or Anad angler if all Great Lakes sites were affected. This is the CCOCV corresponding to a roughly 10% increase in all salmonid catch rates (10% for Chinook, 3.3% for Coho, 13.7% for Lake Trout, and 8.6% for Rainbow). The CCOCV for a 20% catch rate increase in 1991$ will thus be about

$$\$1.084 \times \frac{20\%}{10\%} \times 1.348 = \$2.922$$

This estimate is of the same order of magnitude as those obtained by other researchers.

Map IX.1: Michigan counties affected by the Ludington scenario

Table IX.1: Ludington: Mean compensating variation per trip in 1984 dollars

	N	Day Trip	Wkn Trip	Vac Trip
Day Sample	2463	0.0418	0.1657	0.2417
Wkn Sample	1159	0.0359	0.1666	0.2437
Vac Sample	1202	0.0306	0.1707	0.2427

Table IX.2: Ludington: Total trips per person with plant operation

	N	Day Trip	Wkn Trip	Vac Trip
Day Sample	2463	1.2513	0.5502	0.4423
Wkn Sample	1159	1.1506	0.5675	0.5171
Vac Sample	1202	0.9044	0.4960	0.6831
Total	**4824**	**5502.47**	**2609.01**	**2509.78**

Table IX.3 Ludington: Mean change in season trips

	N	Day Trip	Wkn Trip	Vac Trip
Day Sample	2463	0.0074	0.0013	-0.0014
Wkn Sample	1159	0.0067	0.0013	-0.0017
Vac Sample	1202	0.0053	0.0012	-0.0024
Total	**4824**	**32.34**	**6.10**	**–8.39**

Table IX.4: Ludington: Mean season compensating variation in 1984 dollars

	N	Day Trip	Wkn Trip	Vac Trip
Day Sample	2463	0.1771	0.1407	0.1062
Wkn Sample	1159	0.1328	0.1402	0.1251
Vac Sample	1202	0.0857	0.1150	0.1603
Total	**4824**	**693.179**	**647.25**	**599.28**